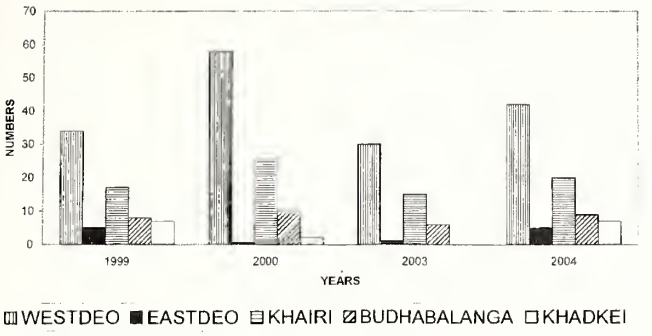


Fig. 2: Distribution of Muggers in the river systems of Similipal Tiger Reserve

disturbance, biotic interference, the presence of *darahs* (deep water area), and adequate basking sites. Though East Deo is also situated in the core area, there are fewer *darahs* and basking places. In Budhabalanga, the riverbank is steep and rocky, the availability of basking places lower, and biotic interference greater. In Khairi, the population of the Mugger is higher from Jenabil to Jadi *darah* in the Jenabil to Ransa route. Here, their number is lower in comparison to the West Deo as the river bed is rocky, providing a smaller area for the basking. But a detailed systematic study has to be made seasonally in order to study the seasonal behaviour and the ecology of the Mugger in the Similipal Tiger Reserve because the crocodile plays the vital ecological role of a master predator in the aquatic habitat where it lives (Whitaker and Andrews 2003).

Moreover, sightings were more in 2000 and 2004 as the census was carried out in March. During this time, the river bank area was more exposed and the temperature was 20° - 30° C, which was suitable for Mugger sighting. The release figure (Table 1) reveals that the population inside Similipal is not related to the release of the Mugger in the wild.

From Table 4 it is seen that during the 2004 census, 33 Muggers within a body length of 1.5 to 2.0 m, and 8 Muggers of more than 2 m body length indicate that 47% are adult. In Tamil Nadu, the wild mugger population is 465 with an adult population of 52% (Andrews 1999), and in Gujarat, the population is 492, with an adult population of 88% (Vijayakumar *et al.* 1990). In Similipal, the recent survey shows that the population is 83 with an adult population of 47%. However, the census shows that the mugger population is stable inside the Similipal Tiger Reserve.

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We specially thank L.A.K. Singh, Senior Research Officer, Office of the Chief Wildlife Warden, Orissa, Bhubaneswar for providing information and guidance in the field. We also thank the field staff of the Orissa Forest Department for their help during the survey. We are grateful to all the students of the Post Graduate Department of Wildlife and Conservation Biology, North Orissa University, Baripada for assistance in field data collection.

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# 16. OBSERVATIONS ON BURROWS DUG BY MUGGER CROCODILES (*CROCODYLUS PALUSTRIS*) IN BUNDALA NATIONAL PARK, SRI LANKA[1]

Rom Whitaker[2], Brady Barr[3], Anslem de Silva[4] and Pradeep Ratnasiri[5]

[1]Accepted December 19, 2005
[2]P.O. Box 21, Chengalpattu 603 001, Tamil Nadu. Email: kingcobra@gmail.com
[3] 4 Fetter Lane, Severna Park, Maryland, USA.
[4]15/1 Dolosbage Road, Gampola, Sri Lanka.
[5]Department of Wildlife Conservation, Uda Walawe National Park, Uda Walawe, Sri Lanka.

During a brief visit to Bundala National Park (Fig. 1), May 7-10, 2002, the authors caught, measured and sexed two mugger crocodiles in burrows. These burrows were measured and mapped, and temperatures recorded, both inside and outside the burrows, for 48 hrs. A total of 38 burrows were seen, which ranged from 3.05 m to over 6.0 m in length.

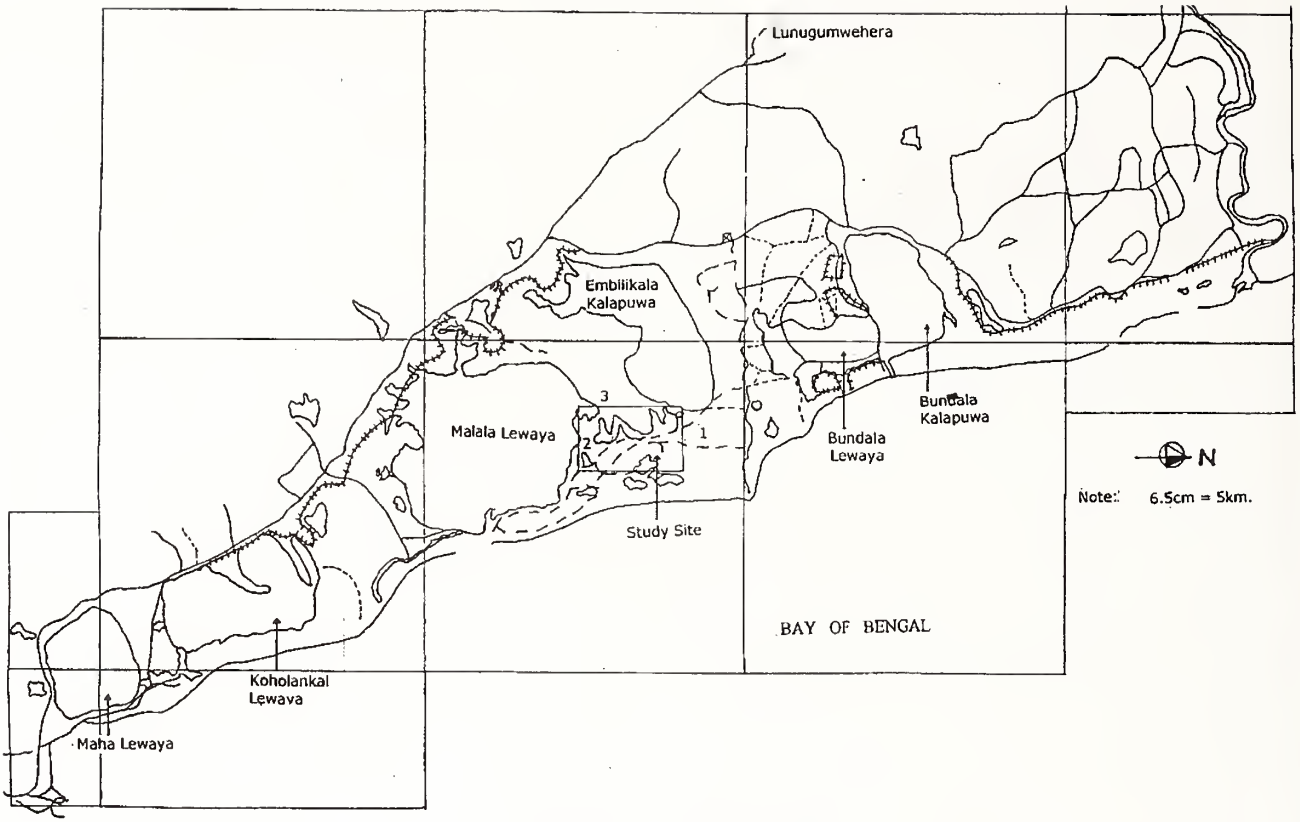


Fig. 1: Bundala National Park, Sri Lanka

Entrances were 45.72 cm to 137.16 cm in width and 27.94 cm to 60.96 cm in height. Temperatures outside the burrows fluctuated from 28° C to 46° C while burrow interiors remained virtually static at 29° C.

It is likely that most of the world's crocodilians dig burrows or tunnels to hide in and to tide over extreme weather conditions (Guggisberg 1972; Steel 1989; Chen *et al.* 1990). Crocodilian species found in the tropics presumably rely on burrows to survive the effects of drought and extreme heat; however, the two species of alligator (*A. misissipiensis* and *A. sinensis*) that range above 30° N where temperatures fall below freezing, dig and utilize burrows as refuges from cold winter temperatures. The mugger crocodile (*Crocodylus palustris*) found throughout the Indian subcontinent, as well as Sri Lanka, is a noted burrow digger. This species presumably utilizes the burrows as an effective refuge from the hot daytime ambient temperatures found in Bundala, Sri Lanka, the southernmost range of *C. palustris*. Crocodilians have an optimum body temperature of 30-35° C, and if subjected to temperatures below 5° or above 38° C for extended periods, they are in danger of dying (Lang 1987). Burrows may play a critical role in the survival of crocodiles living in harsh environments, such as southern Sri Lanka.

There are numerous references to mugger burrows in the literature, a few of which follow: Deraniyagala (1936) describes the U-shaped mugger burrow found in riverbanks in Sri Lanka often under the roots of the typical riparian tree giant, *Terminalia arjuna*. McCann (1940) mentions mugger burrows at the Sind salt lakes (now Pakistan). Whitaker (1977) describes finding sixteen mugger burrows in the Hiran Lake, Gir Lion Sanctuary in Gujarat with "flattened, oval entrance" averaging 80 cm width and 4 to 5 m deep. There was a croc in nearly every tunnel at the end of May 1975 and outside temperatures were reaching 46° C in the shade. Whitaker and Whitaker (1984) referred to mugger burrows in Sri Lanka, Gujarat, South India and noted that yearling, subadult and adult mugger all dig burrows. They briefly describe the tunnelling, the crocodile using its front feet to dig and push earth back to the hind feet which scrape the dirt back to where the tail propels it away into the water. Gupta and Srihari (1990) studied mugger burrows at Bhorsaindan Sanctuary, Haryana and found that burrow utilization was greater in winter months when temperatures dropped to 11° C. Shekar (1993) reported two to six muggers in the same burrow in winter months at this Sanctuary. Vijaykumar (1997) enumerated 114 mugger burrows in different parts of Gujarat. Most burrows were from 0.6 m to 2.6 m in depth, though two in Gir Sanctuary were over 6 m. He mentions that the temperature inside a 3 m burrow remained constant at 19.2 to 19.8° C while the outside temperature fluctuated from 12 to 43° C. He gives no date but

judging from the temperature and the fact that most burrows were empty it was probably in February, before the serious dry season sets in.

**Methods**

With the permission of the Department of Wildlife Conservation, Sri Lanka and help from the Bundala National Park Warden and staff we visited three main burrow sites by a 4-wheel drive vehicle and on foot (Fig. 2). Several burrows were measured from the burrow mouth, and two of the larger ones were entered and mapped. These two large tunnels contained crocodiles which were caught, measured, sexed, marked and released on site. Two other free swimming crocodiles were caught with swivel-lock wire nooses to demonstrate safe capture, sexing, marking and release techniques to the NP staff. Data loggers (Stowaway Tidbit loggers, Onset Computer Corporation) recorded temperature simultaneously at 30-minute intervals for 48 hours and were placed inside and outside burrows and in the water close to the tunnel mouths. Sexing was done by digital probing of the cloaca.

**Results**

**Site 1**: Local name: Sudugala

**Description**: raised 50 m long embankment of sand and black soil about a metre above present water level (it had rained a few days earlier), facing southwest. Water channel in front of embankment 12 m wide and 25-50 cm deep, fresh. Vegetation: *Prosopis juliflora* (mesquite), *Salvadora persica*, reeds (dry now) and small bushes.

Mapping of sample burrow (No. 1 at North end)

| | Height (cm) | Width (cm) |
|---|---|---|
| Entrance | 37.5 | 70.0 (2.5 m from water's edge) |
| 2 metres in | 32.5 | 90.0 |
| 4 metres in | 37.0 | 105.0 (chamber) |

**Burrows**: Five burrows, three were occupied and two crocodiles about 2 m length were observed in the adjacent water. Burrow entrances ranged from 25-40 cm in height and 35-70 cm in width. Two of the burrows were at water level, three were dry.

Crocodile pulled out of this burrow was a 2.70 m female missing about 15 cm of its tail end and clipped by us on the 6th dorsal caudal whorl on the left.

Crocodile caught in adjacent water was also a female, 2.40 m in length and clipped on the 8th dorsal caudal whorl on left.

**Site 2**: Local Name: Campsite

**Description**: Raised 75 m long embankment of sand and black soil 2 m above present water level facing north-west. Water and channel 20 m wide and 1 to 1.5 m deep, fresh. Vegetation: same as Site 1 with *Phoenix* sp. (dwarf date palms).

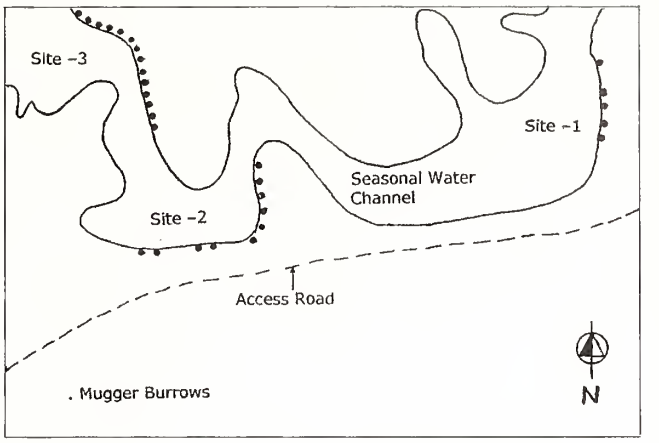


Fig. 2: Detail of study site, Bundala National Park

**Burrows**: 10 burrows, 1 occupied plus 4 crocodiles 1.5 to 2.5 m in the adjacent water. Burrow entrances were mostly above present water line and ranged from 20-40 cm in height and 28-135 cm in width. Depth of one was more than 6 m.

Crocodile pulled out of this burrow was a 2.35 m female with a mangled 4th single caudal whorl (for I.D.). Temperature loggers were placed in the water and on the substrate (unshaded) outside the burrow and at three depths inside the burrow. Results are given in Figs 4 and 5.

**Site 3**: Local Name: Campsite Tuduna (point)

Mapping of sample burrow
(No. 2 from North end under *Phoenix* palm – Fig. 3)

| | Height (cm) | Width (cm) |
|---|---|---|
| Entrance | 40.0 | 135.0 |
| 2 metres in | 42.0 | 77.5 |
| 3 metres in | 27.5 | 72.5 |
| 5 metres in (chamber) | 82.0 | 114.0 (partly caved in) |

**Description**: Raised 160 m embankment of sand and dark soil 1.5 to 2 m above present water level facing west – south-west. Water channel about 25 m wide and 1 m deep, slightly brackish. Vegetation: mainly *Prosopis* and small bushes.

**Burrows**: 23 burrows, 3 occupied, 2 crocodiles *c.* 2 m in water. All entrances were above the present water level. Entrance height ranged from 23 cm to 60 cm, widths from 28 cm to 77 cm. Burrow depths 3-5 m.

**Other animal life observed in the burrows**: Gecko, centipedes, mosquitoes, cockroaches, and ants.

**Discussion**

Mugger dig burrows of sometimes more than 6.0 m in

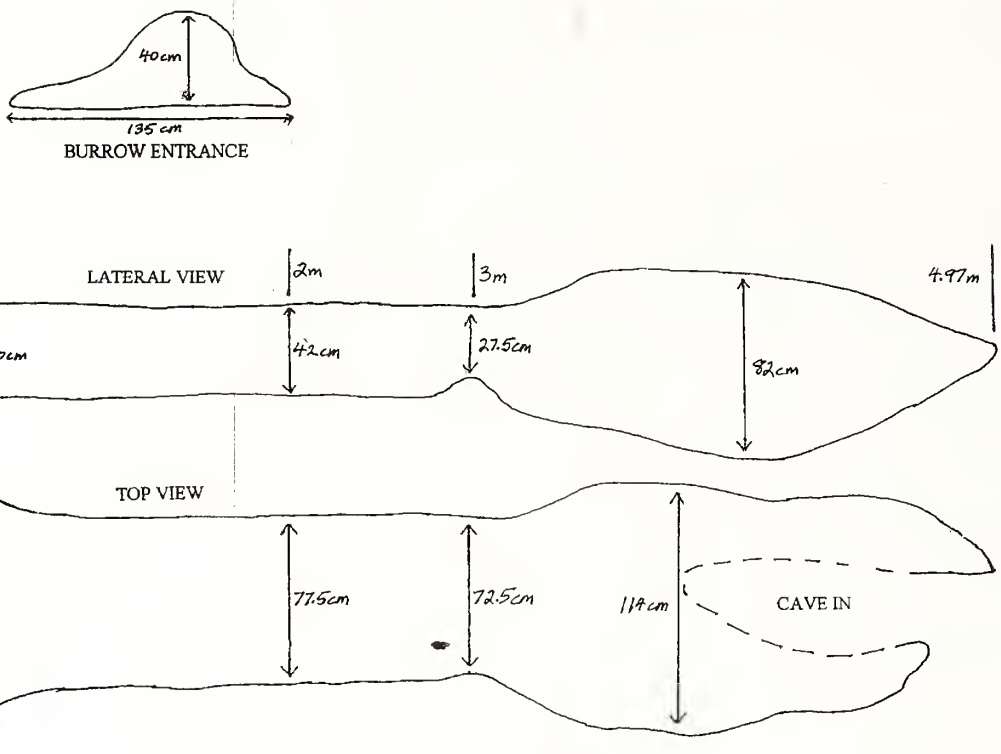


Fig. 3: Burrow 2 (site 2) interior map (not to scale)

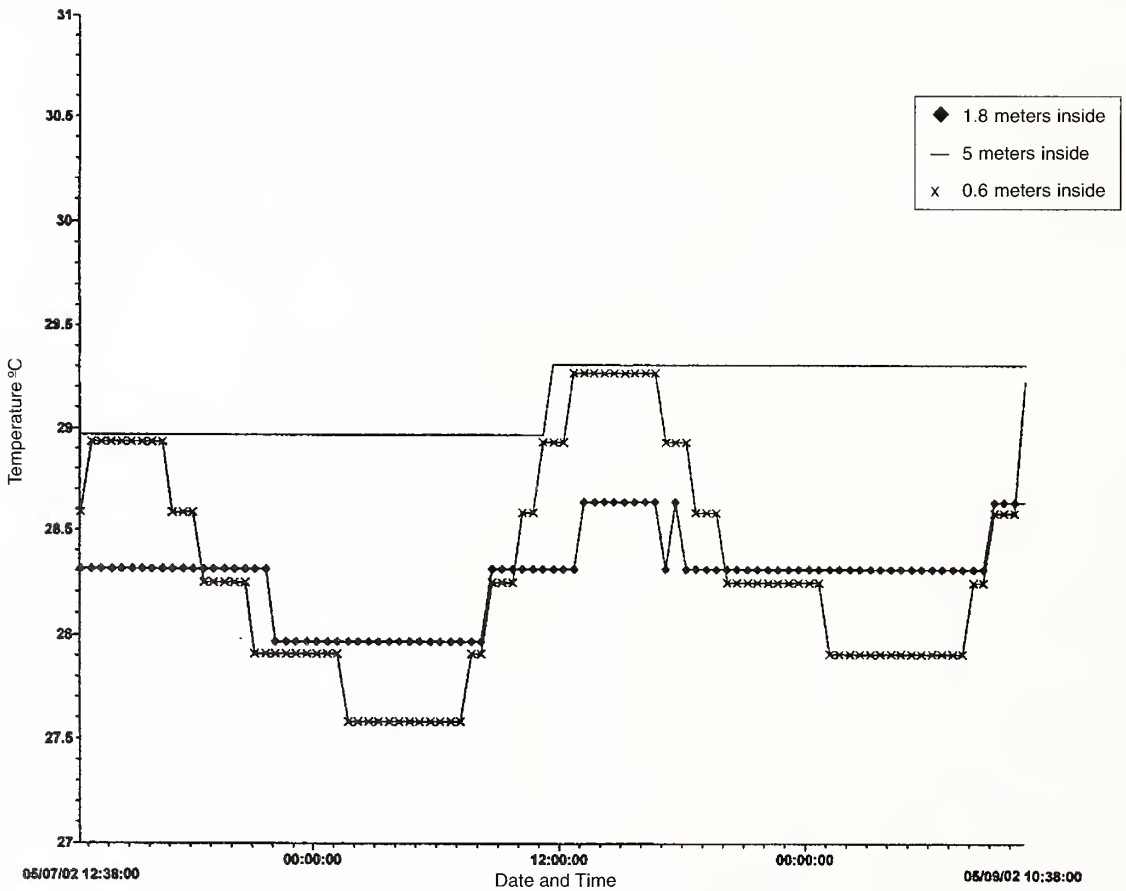


Fig. 4: Burrow 2 (site 2) temperature readings inside burrow

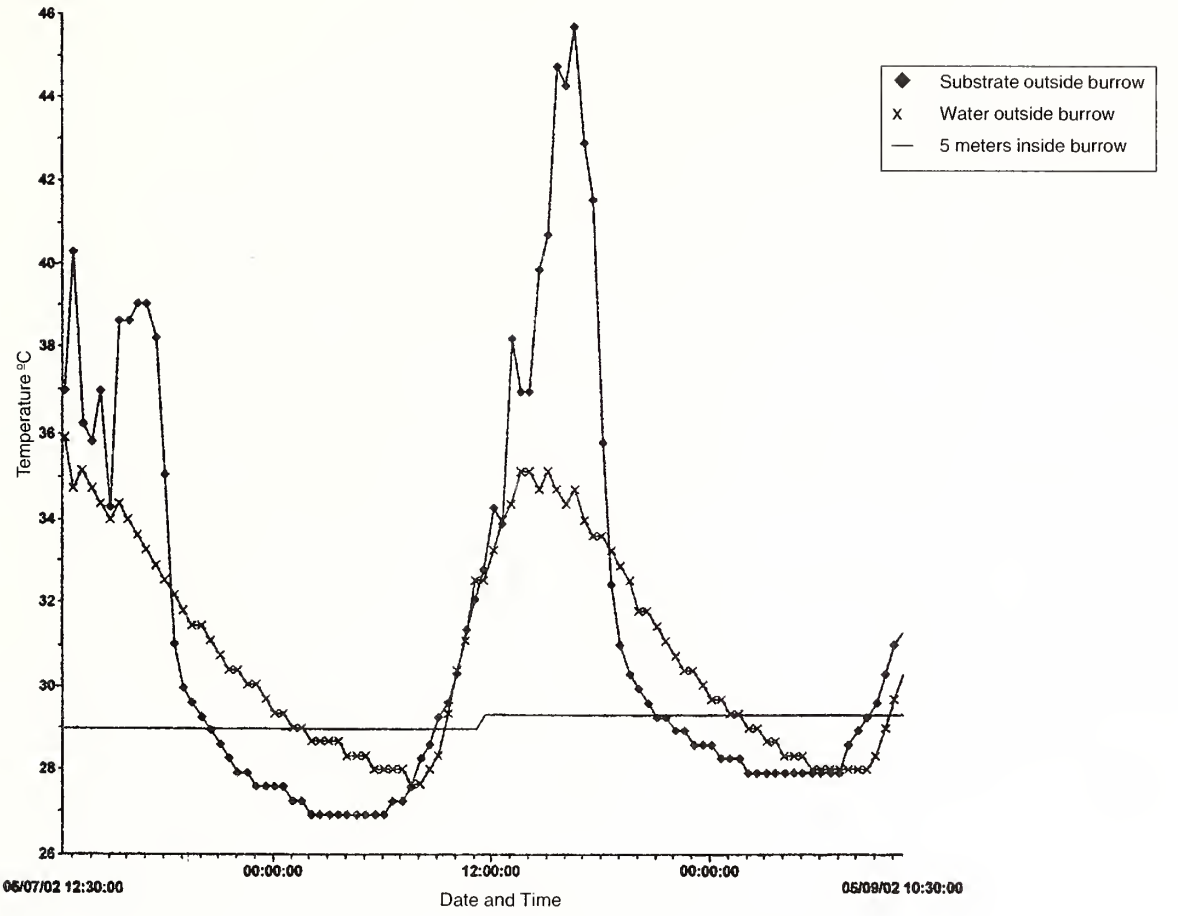


Fig. 5: Burrow 2 (site 2) bihourly temperature readings

length to escape the heat and desiccation of sometimes very long and harsh dry seasons in South Asia. The burrows observed in this study were clean with no smell and with varying degrees of dampness. Few of them were occupied which is likely to be because of the recent rains and lower temperatures. Most burrows showed signs of recent occupation and some of recent digging. Invariably the deeper burrows sloped downward at the end, with a larger chamber up to double the width of the tunnel for the crocodile to turn around and comfortably lie in. Very often deeper burrows turned so that the end was not visible. One characteristic of most tunnel entrances is the raised central mound of earth or sand. This is formed as the crocodile enters the tunnel and digs with front and hind limbs, as it goes in. Digging seems to be a continuous process and it is likely that some burrows took several years to dig and may be in use for decades or more. It is surmised that tunnels are used as occasional refuges at this time of year with the more permanent residents moving in at the July-October period of peak hot weather. Several observers (Shekar 1993; Vijaykumar 1997; Whitaker *in litt.*) noted that female mugger will lay their eggs at the mouth of their tunnel, a strategy that can optimize nest and hatchling survival.

The graphs showing the data from the loggers (Figs 4 and 5) are self-explanatory. The two things that stand out are (a) the amazing consistency of temperatures deep within the burrows (not coincidentally, optimum for a crocodilian) and (b) a sudden small rise in temperature near midnight in one burrow, which could have been the entry of a crocodile.

A behavioural observation of considerable interest is that when we approached adult muggers in shallow water they would first attempt to swim away, but failing to find deep water they would leave the water to enter a nearby tunnel or if no tunnel was present they would simply walk up into the forest for shelter, more like a big lizard than a crocodile! In one case a large female got herself entangled in some bushes and we were able to ascertain her sex without catching or restraining her.

Some burrows were observed to have unstable roofs in danger of collapse. Numerous collapsed burrows were seen (mostly old) probably due to heavy rains. One of the authors (Pradeep) has counted over 90 mugger burrows in

Bundala NP and another (Whitaker) enumerated burrows in the Menik Ganga (Yala NP) and Lunugumvehera NP. These observations and the results of this small study point to a fascinating and important behaviour by mugger which deserves systematic study. A comprehensive investigation focussing on the role of burrows in relation to the thermal ecology of crocodilians is sorely lacking and Sri Lanka offers a unique opportunity. The mugger cannot survive extended dry seasons without being able to regulate its temperature within safe limits. In a hot, dry area like Bundala their burrows are a vital refuge. Protection of the embankments in the Park is important for the long-term conservation of the species.

**ACKNOWLEDGEMENTS**

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## 17. A REPORT OF *GECKOELLA NEBULOSA* (BEDDOME, 1870) FROM SEONI DISTRICT, MADHYA PRADESH[1]

Ishan Agarwal[2]

[1] Accepted June 13, 2005

[2]5/44, Hira, K.C. Road, Mumbai 400 050, Maharashtra, India. Email: ishan_a@rediffmail.com

On October 30, 2003 a freshly killed *Geckoella nebulosa* (Das 2003) was seen near a pile of rocks, close to a road near Seoni (22.06° N, 79.35° E), just outside Pench National Park.

The specimen was collected and deposited in the collections of the Bombay Natural History Society (Regn. No.: BNHS 1598). The forest type in Seoni district is Tropical Dry Deciduous and Tropical Moist Deciduous, largely dominated by *Tectona grandis* (Champion and Seth 1968). The area in which the gecko was found was a shady, forested patch, with little undergrowth, dominated by *Tectona grandis*.

The lizard measured 37.3 mm snout-vent length, and 27.2 mm tail length. The specimen agrees with Smith's (1935) description – 10 supralabials on both sides, 38 midventrals, back with small granular scales interspersed with numerous larger rounded tubercles. A notable discrepancy is that the specimen has 8 infralabials on each side, as against 10 in Smith (1935). The coloration is also the same as Smith (1935), except the tail tip was bright orange.

Other reptiles seen in the same area were *Sitana ponticeriana*, *Psammophilus blanfordanus*, *Hemidactylus brookii*, *Calotes versicolour*, *Mabuya carinata* (visual identification) and a shed skin *of Ptyas nucosus.*

This gecko was originally described as *Gymnodactylus nebulosa* from Golconda Hills (Andhra Pradesh) by Beddome in 1870. Further distributional records are as follows: Nelambo, South India (= Andhra Pradesh): Annandale (1913), Smith (1935), Tikader and Sharma (1992); Gorge Hills, Godavery and Russelconda in Andhra Pradesh: Smith (1935), Tikader and Sharma (1992); Mandla district, Madhya Pradesh (adjacent to Seoni district): Sharma (1976), Tikader and Sharma (1992); Kerala (Nilambur, Malappuram district) and Tamil Nadu (Saidapet district): Tikader and Sharma (1992); Koraput district, Orissa: Sanyal (1993); Puri district, Orissa: Dutta (1997). Das (2002) gives the distribution of this species from Puri and Koraput district in Orissa, to Gorge, Golconda and other isolated hills in Andhra Pradesh. The University of Michigan